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Note on Projections illustrating the presentation of the Planet Mars during the year 1873, *and showing the Martial Lands and Seas which will be in view at different Epochs.* By Richard A. Proctor, B.A. (Cambridge).

Although the opposition of the planet *Mars* during the year 1873 is not a particularly favourable one, the planet being nearer the aphelion than the perihelion of its orbit, yet there are some circumstances which render it particularly desirable that the planet should be carefully studied on this occasion.

In the first place, the planet will be passing through the autumn months of its northern hemisphere, that is, the months between Martial midsummer and the autumnal equinox. On this account the opportunity is a favourable one for studying the north-polar region of the planet, the errors there being probably much reduced in extent, and presumably the true place of the pole more satisfactorily indicated than usual.

Then, secondly, the northern half of the planet is now fairly turned towards the Earth, and is likely to be clear of Martial clouds and mists, insomuch that the shape of the lands and seas on this the least-known half of the planet can now be satisfactorily determined.

On this account I have thought it desirable to prepare the accompanying table and diagrams as a guide to intending observers of the planet during the opposition of 1873.

The diameters and the illuminated portion of the disk, in the plate, have been taken directly from the *Nautical Almanac*.

The elements on which the determination of the axial position of *Mars* has been based are those given in No. 858 of the *Astronomische Nachrichten*, in a paper by Dr. Oudemans upon the observations made by Bessel with the Königsberg heliometer between the years 1830 and 1837. He gives (as quoted in a note by Mr. Hind in 1867),

	°	′	
Longitude of pole of *Mars* .	349	1	for ecliptic.
Latitude . . .	61	9	

Assuming these numbers to apply to 1834·0, we find,

	° ′
Longitude of ascending node of Equator of *Mars* upon his orbit (λ′)	80 50·4
Obliquity of Martial ecliptic (I′) . . .	27 16·5

And hence

	° ′
Ascending node of Equator of *Mars* on the Earth's Equator (N)	47 33·9
Inclination (I)	39 55·6

For 1873·0 + *t* these values give

$$N = 47^\circ\ 53' + 0{\cdot}50\ t$$
$$I = 39\ 43 - 0{\cdot}25\ t.$$

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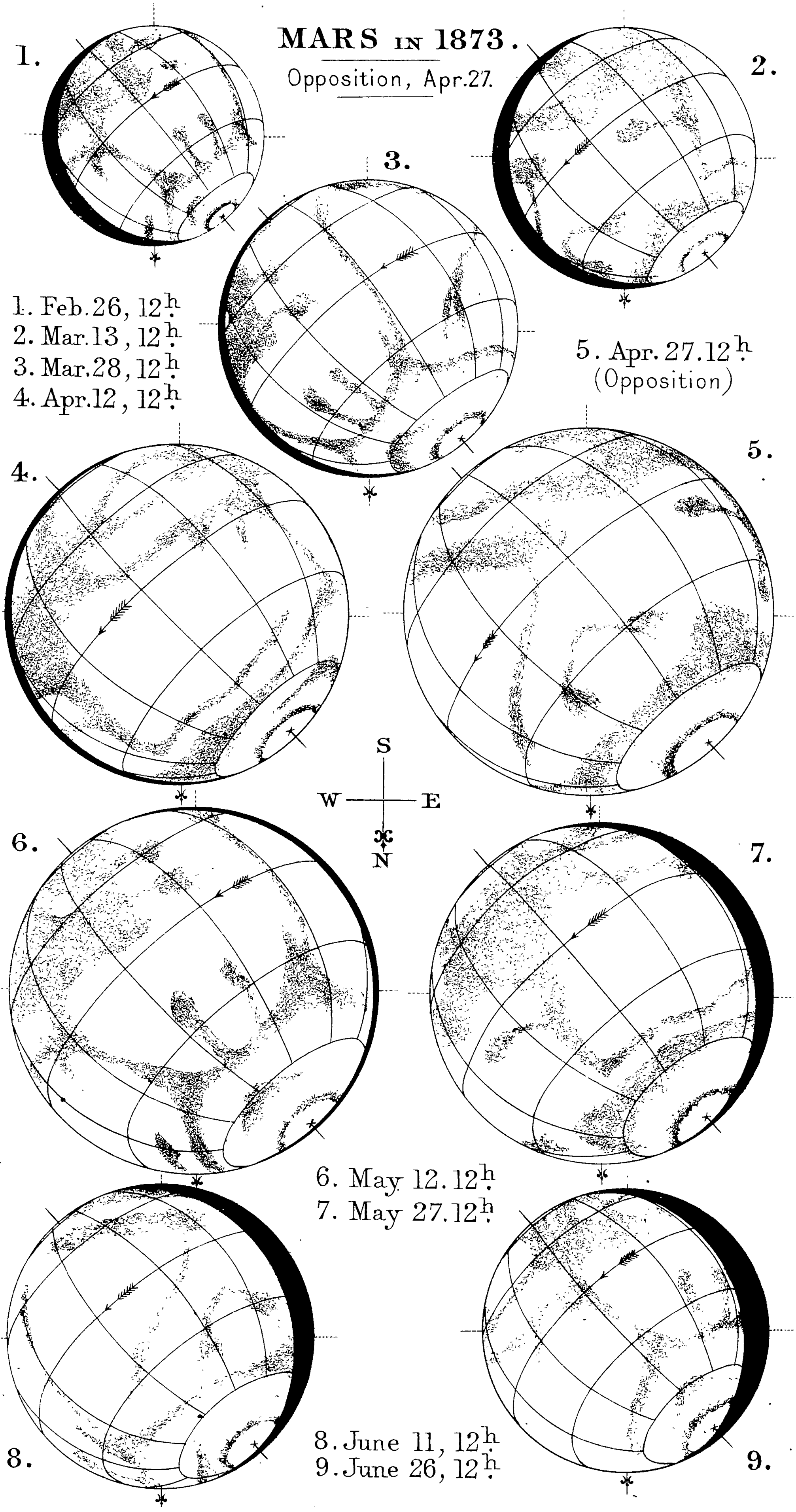
MARS IN 1873.

Opposition, Apr.27.



1. Feb.26, 12^{h}.
2. Mar.13, 12^{h}.
3. Mar.28, 12^{h}.
4. Apr.12, 12^{h}.

5. Apr. 27. 12^{h}.
(Opposition)

6. May 12. 12^{h}.
7. May 27. 12^{h}.

8. June 11, 12^{h}.
9. June 26, 12^{h}.

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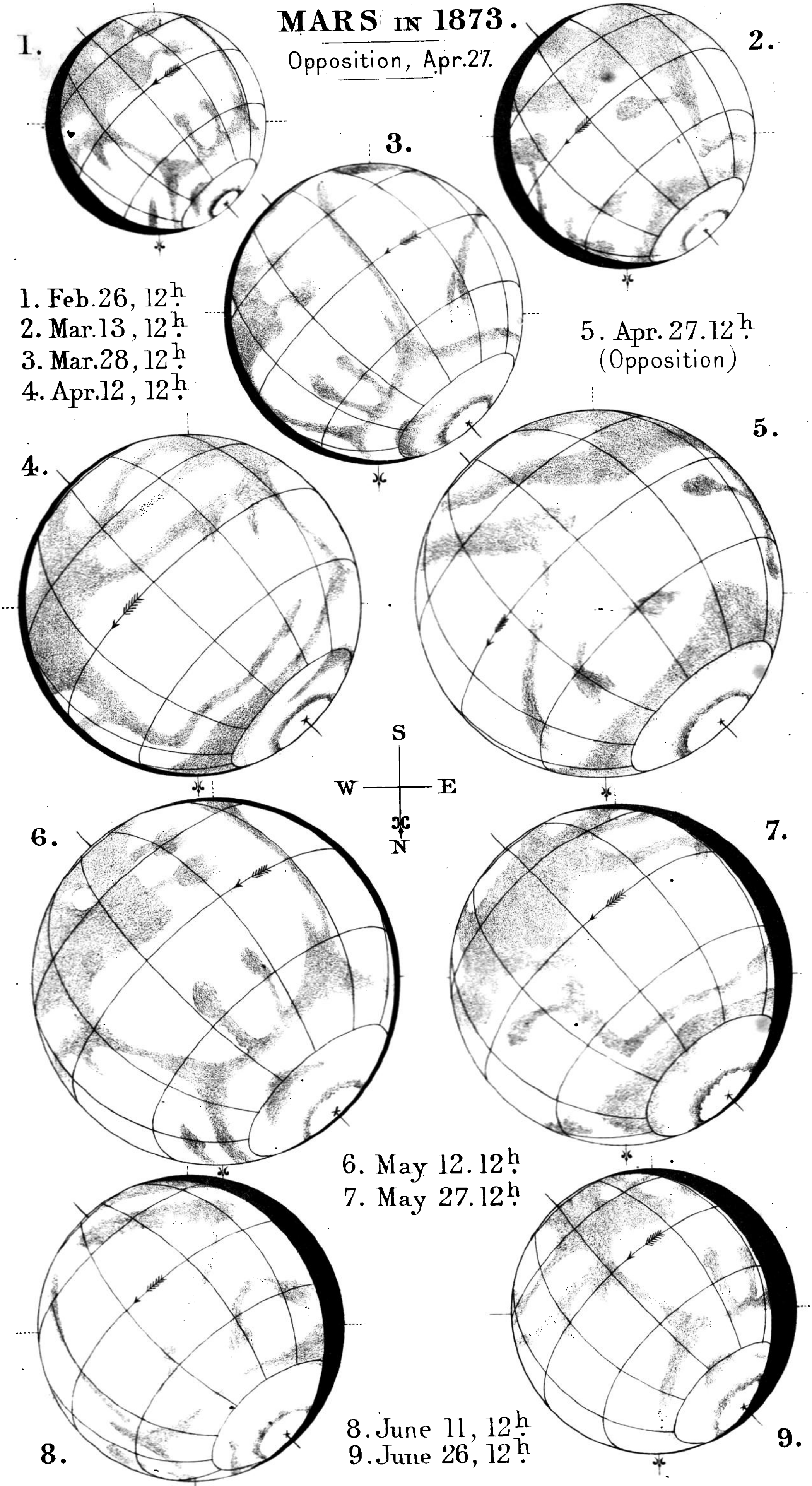

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I have adopted these values in the computation of p and l in the accompanying table; p being the apparent inclination of the axis of *Mars* to the circle of declination, and l the elevation of the Earth above the equator of the planet; using the following formulæ:—

Let α be the geocentric Right Ascension of *Mars*
δ ,, Declination ,,

and Q an auxiliary angle such that

$$\tan Q = \tan i \, . \, \sin(\alpha - N)$$

then

$$\tan p = -\frac{\sin Q}{\cos(Q - \delta)} \cot(\alpha - N)$$

and

$$\tan l = \tan(Q - \delta) \cos p.^{*}$$

Moreover, if l' be the elevation of the Sun above the plane of the ring, λ the heliocentric longitude of *Mars*, then, with sufficient approximation,

$$\sin l' = \sin(\lambda - \lambda') \sin I'.^{\dagger}$$

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[*] These formulæ are given by Mr. Hind in the note referred to above, and are the same as are used in the *Nautical Almanac* for determining the position and phase of *Saturn's* ring. (They are given in full, with others, among the explanations of the tables in my Treatise on *Saturn*.) But in Mr. Hind's note, by an inadvertency, the denominator in the expression for tan p is written sin $(Q - \delta)$. The following formulæ can be used, if preferred:—

$$\begin{aligned} \cos l \, . \, \sin p &= - \sin I \, . \, \cos(\alpha - N) \\ \cos l \, . \, \cos p &= \sin I \, . \, \sin(\alpha - N) \sin \delta + \cos I \cos \delta \\ \sin l &= \sin I \, . \, \sin(\alpha - N) \cos \delta - \cos I \sin \delta. \end{aligned}$$

[†] Strictly speaking, formulæ corresponding to those given at p. 229 of my treatise on *Saturn* should be employed, viz., putting

β = *Mars'* heliocentric latitude,

ν = longitude of ascending node of *Mars'* orbit on ecliptic,

and ☊′ = arc from ascending node of *Mars'* orbit on ecliptic to ascending node of *Mars'* equator on his orbit.

Then assuming

$$\cos \Psi = \cos(\lambda - \nu) \cos \beta$$

we have

$$\sin l' = \sin(\Psi - \text{☊}') \sin I'.$$

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Date. Greenwich. Noon. 1873.		p.	l.	l'.	$\lambda - \lambda'$.
Feb.	26	41° 4′ W.	15° 7′ N.	25° 47′ N.	108° 21′
Mar.	13	41 3	14 7	24 29	115 12
	28	41 4	14 15	22 49	122 10
April	12	41 10	15 34	20 47	129 15
	27	41 0	17 57	18 23	136 29
May	12	40 31	20 30	15 40	143 53
	27	40 2	22 18	12 30	151 27
June	11	40 2	22 59	9 21	159 13
	26	40 33	22 36	5 50	167 11

It will be seen that the value of p changes very little during the four months. Usually p changes largely. Thus in the opposition-period of 1866–7, p ranged in value between 9° 50′ and 21° 52′. The reason of the approach to constancy in the value of p during the present opposition is readily seen on a consideration of the accompanying figure, which shows the varying position of the line joining the Earth and *Mars*. This needs no explanation, so far as those are concerned for whom this paper is specially intended.*

It will furthermore be noticed that while l' continually diminishes, as *Mars* passes from the neighbourhood of his midsummer place to that of his autumn place (for his northern hemisphere), l first diminishes, afterwards increases, and then diminishes again. This also is explained by the figure. It will be seen, also, how in the illustrative plate the boundary between the illuminated and the dark parts of *Mars*' disk accords with the values of l and l'.

The woodcut shows the method by which the areographic features of *Mars* for the epochs indicated in the plate have been determined from an observation of *Mars* made on February 23, 1867, at 6^h 45^m P.M. by Mr. Browning. (The hour in each case is midnight, Greenwich mean time.) The picture of *Mars* then obtained is shown in Plate II. of my *Essays on Astronomy*. Between the date of that observation and April 27, 1873, midnight, there is an interval of 194850900 seconds. Taking the rotation period of *Mars* as 88642·73 seconds, I find that the number of rotations of *Mars* amounts to 2198 + a rotation through 57°. I take the Kaiser Sea as 21° from the central meridian in Mr. Browning's picture (approaching the meridian), and the line joining the Earth and *Mars* on April 27 makes an angle of about 117° with the corresponding line on February 23, 1867. This obviously amounts to setting *Mars* 117° *back* in rotation. Thus, instead of 2198 Rot. + 57°, we have 2198 Rot. — 60°, or the Kaiser Sea 81° from the central meridian, instead of 21° as on

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* In a paper which will appear in the *Quarterly Journal of Science* for April, this and the other relations illustrated by the figure will be found fully explained.

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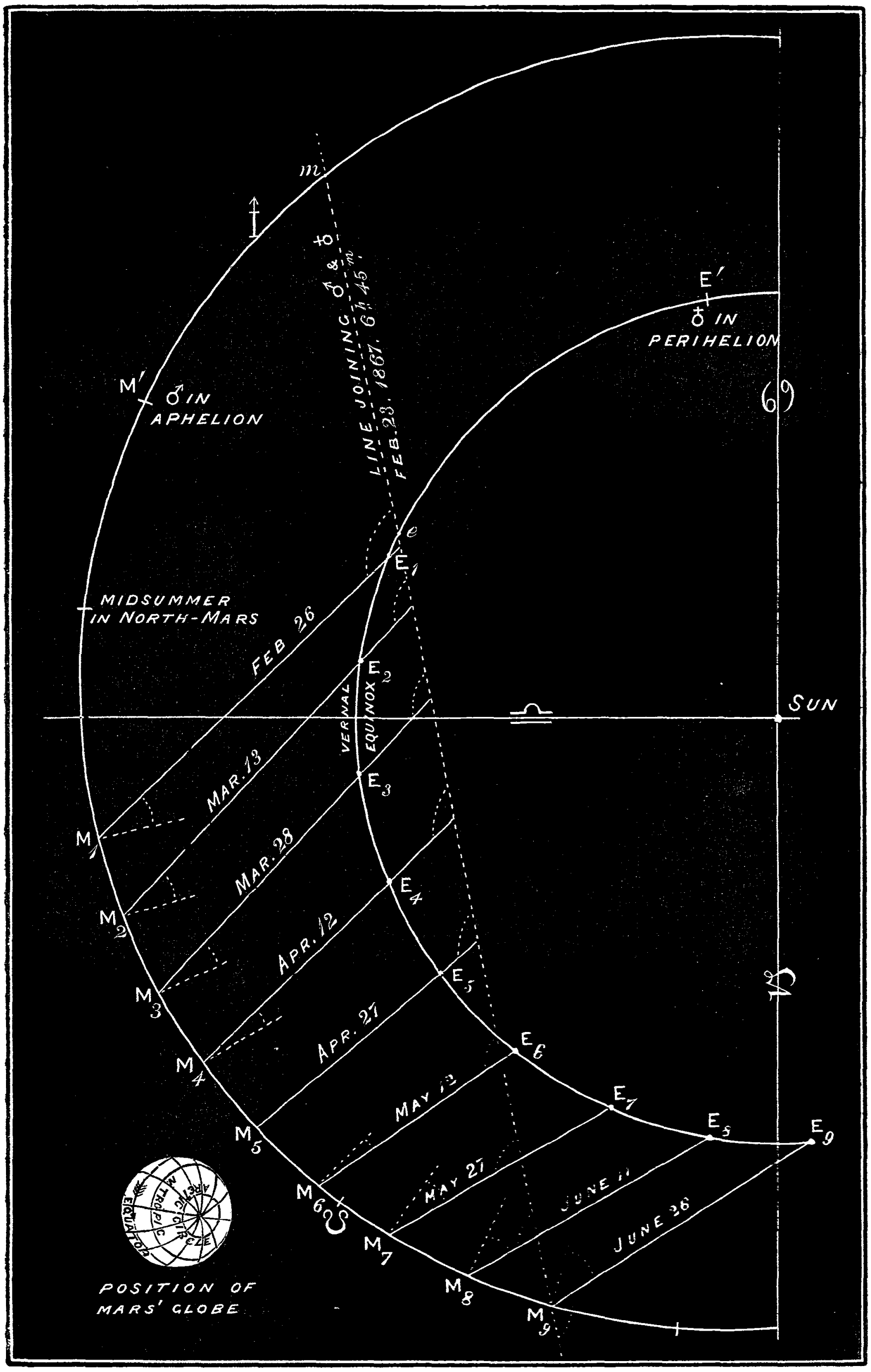
Feb. 23, 1867, at 6^h 45^m. The picture of *Mars* for April 27, No. 5 of the plate, corresponds with this result. The others have been



Illustrating the motions of the *Earth* and *Mars* during, March, April, May, and June, 1873.

obtained from similar considerations, account being taken in every case of the changing bearing of *Mars* from the Earth.